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Impact of CIR/CME-like features on the ionospheres of Venus, Mars and Titan

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Abstract

During the last solar minimum we use ACE data to track high-pressure events in the solar wind, which are predominantly identified as corotating interaction regions (CIRs) and some as coronal mass ejections (CMEs). These pressure pulses propagate outward in the solar system and eventually impact on planetary atmospheres. By studying the fluxes of heavy ions in the antisunward direction around Mars and Venus we can show that when these pressure pulses impact on the planets the atmospheric escape rate increases by a factor of 2.5 and 1.9, respectively. We also make the analogy to Titan and predict the ionospheric escape rate varies depending on the phase of the Saturn Kilometric radiation. Furthermore, we suggest that dayside magnetic reconnection could occur during each event, as they are usually associated with a rotation of the magnetic field, which drapes around the ionosphere.

1. Introduction

As the tilted Sun rotates it periodically emits plasma from either the Sun's equatorial regions or the high-latitude regions, as seen from one specific location in space. The plasma from the high latitude regions is generally streaming faster than the equatorial plasma such that the faster plasma will inevitably catch up with slower flowing plasma. At the interaction region between these two streams is the plasma density and temperature as well as the interplanetary magnetic field generally increased such that the total pressure is increased. This so called co-rotating interaction region (CIR) propagates outward in the solar system and acts as solar wind pressure pulse. It will eventually impact on any obstacle present in the solar systems, such as the planets Mars and Venus [1,2].

2. Observations

We have used data from the Advanced Composition Explorer (ACE) upstream of Earth to identify such events in the solar wind during the last solar minimum. By measuring their propagation speed and taking into account the relative positions of Earth and Mars, and Earth and Venus, we can predict when these events will impact on Mars in order to determine what effect they have on the planet. The prediction is also verified through a by-eye search in the electron measurements from the ASPERA-3/4 ELS instrument on the MEX/VEX.

Since we know when these pressure pulses are impacting on Mars and Venus, we can use the ion measurements from the ASPERA-3/4 IMA instrument to study what happens to the heavy planetary ions during such impacts, in terms of their escape rate. By comparing the escape fluxes during the impact of CIRs with the escape fluxes during quiet solar wind conditions, as is shown for Mars in Fig. 1 and Venus in Fig. 2, we find that the escape rate increases by a factor of 2.5 and 1.9.

We discuss whether it is the increased solar wind dynamic pressure that causes the increased escape rate or if it is an effect of the concurrent rotation of the interplanetary magnetic field. The magnetic field rotation causes the induced magnetosphere to reconfigure and change polarity, which could trigger reconnection events and substorm-like processes. During such processes plasma can be accelerated in the downstream direction through electrodynamic effects.

At Titan, the upstream plasma parameters also vary with time. As Titan is located within Saturn's magnetosphere Titan's ionosphere is interacting primarily with the corotating plasma of Saturn, which varies with the SKR phase. This might lead to similar variability in the ionospheric escape rates as for Mars and Venus during solar wind pressure pulses.

3. Figures

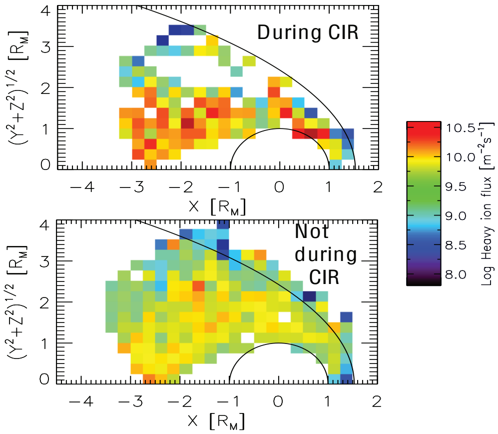

Figure 1: Heavy ion fluxes observed around Mars during (top) the impact of CIRs and (bottom) during quiet solar wind conditions.

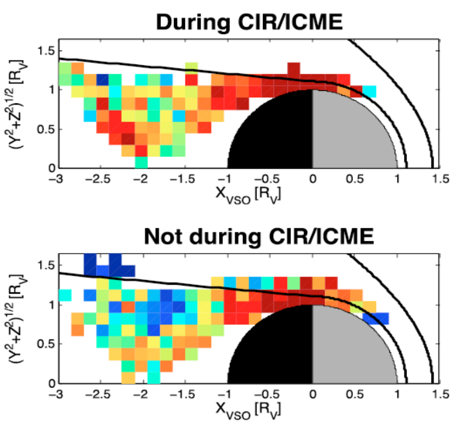

Figure 2: Heavy ion fluxes observed around Venus during (top) the impact of CIRs and (bottom) during quiet solar wind conditions.

4. Summary and Conclusions

In this paper we have shown that the impact of solar wind pressure pulses, like CIRs or CMEs, have a significant effect on the evolution of Mars' and Venus' atmospheres. We find that the escape rate of heavy planetary ions increase by a factor of 2.5 and 1.9 respectively when the planet is impacted by a solar wind pressure pulses. Similar processes might occur a Titan.

Acknowledgements

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